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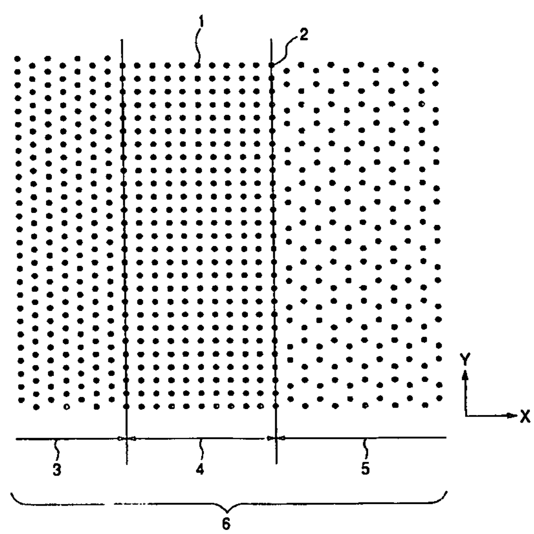
(54) Title: STRUCTURE, OPTICAL DEVICE, MAGNETIC DEVICE, MAGNETIC RECORDING MEDIUM AND MANUFACTURING METHOD THEREOF



(57) Abstract: A nano structure having pore array structures in which a plurality of periodic arrays are formed adjacent to one another and a method of manufacturing the nano structure are provided. A nano structure having periodic array structures of pores formed in an anodized oxide film with a plurality of types of the periodic array structures arranged adjacent to one another is provided. Furthermore, a method of manufacturing a nano structure in which a plurality of periodic array structures formed in an anodized oxide film having different periods are arranged adjacent to one another, including (1) a step of forming pore starting points made up of a plurality of types of periodic arrays on the surface of a substrate comprised of aluminum as a principal component and (2) a step of anodizing the substrate simultaneously at the same anodization voltage is provided.

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DESCRIPTION

STRUCTURE, OPTICAL DEVICE, MAGNETIC DEVICE, MAGNETIC RECORDING MEDIUM AND MANUFACTURING METHOD THEREOF

TECHNICAL FIELD

The present invention relates to a structure having concavo-convex structures on the order of nanometers arranged at intervals on the scale of nanometers (hereinafter also referred to as "nano structure"), an optical device, a magnetic device, a magnetic recording medium and a method of manufacturing the structure.

BACKGROUND ART

As a technology of forming nanostructure or microstructures on the surface of an object, a technology of forming pores of several hundred nm or less in size using an anodization for a film or substrate comprised of aluminum as a principal component rather than a lithography technology using light rays or electron beams is conventionally known.

The anodization method is a method applying an electric field to a substrate comprised of aluminum as a principal component as an anode in an acid bath

oxidation and a dissolution phenomenon and form pores on the surface of the substrate. These pores are formed straightforward in the vertical direction starting from the surface of the substrate, have a high aspect ratio and also have excellent uniformity in diameters of their cross sections. Furthermore, it is possible to control the diameters and spacing of pores by adjusting a current and/or voltage during anodization and control the thickness of an oxide film and depth of pores by controlling the duration of anodization, to a certain extent.

The positions of pores formed using this technique are random, but a technique for obtaining regularly arrayed pore structures is proposed in recent years. This technique forms regularly arrayed concave structures on the surface of a substrate comprised of aluminum as a principal component using an optical lithography and imprint lithography, etc., and conducts anodization using these structures as starting points of pores (USP6139713).

There are proposals on various applications focused on a specific geometric structure of this anode alumina and detailed explanations are given by Masuda et al.

Examples of this include an application for a film which takes advantage of wear resistance and insulating properties of an anodized oxide film and

an application for a filter with a film peeled off. Attempts are also made using a technology of filling pores with metal, semiconductor or magnetic substance or replica technology of pores for various applications including coloration, magnetic recording medium, EL light-emitting device, electrochromic device, optical device, solar cell, gas sensor, etc. Moreover, a wide variety of applications such as quantum effect devices such as quantum wire and MIM device, molecular sensor using pores as a chemical reaction field, etc., are expected.

A longitudinal recording system, which is the current mainstream of magnetic recording media, becomes more liable to demagnetization as the recording density increases and limitation of its recording density is pointed out. As an alternative technology, there is a proposal on a perpendicular magnetic recording system which records data by magnetizing a recording medium in the vertical (film thickness) direction. According to this system, the demagnetizing field decreases and a more stable state is produced as the recording density increases as opposed to the conventional longitudinal recording system. Furthermore, this system can also increase the thickness of the recording film compared to the longitudinal recording system, and therefore it is said to be resistant to thermal fluctuations in

principle. There is a proposal on an application of an anodized oxide film for a perpendicular magnetic recording medium using such a perpendicular magnetic recording system (Japanese Patent Application Laid-Open No. H11-224422).

The above described nano structure is generally formed using a lithography technology and etching technology, but using such techniques, it is extremely difficult to form a high aspect structure which is realized by the anodization method.

Furthermore, the above described magnetic recording medium is disk-shaped and the rotator when information is recorded or reproduced is subject to fine vibration or eccentricity, which prevents recorded tracks from becoming concentric, producing position errors of the head and tracks. Similar position errors are also produced by deformation due to expansion of the disk caused by a thermal distribution in the apparatus. Therefore, the recording area is divided into data areas for recording information and servo areas for detecting track positions and positions are corrected while the head is detecting position information of tracks, but patterned media which are being developed in recent years have a problem as to how to construct servo areas.

The present invention has been implemented in

view of the above described problems and it is an object of the present invention to improve the above described points and provide a nano structure having pore array structures in which a plurality of periodic arrays are formed adjacent to one another.

Furthermore, the present invention also provides a method of manufacturing a nano structure in which a plurality of periodic arrays are formed adjacent to one another in a short time by applying anodization to pore starting points formed on a substrate all together at one anodization voltage.

Furthermore, the present invention also provides an optical device with the pores having the nano structure filled with a dielectric having a dielectric constant.

Furthermore, the present invention also provides an optical device with the pores having the nano structure filled with a light-emitting material.

Furthermore, the present invention also provides a magnetic device with the pores having the nano structure filled with a magnetic material.

Furthermore, the present invention also provides a magnetic recording medium capable of constructing effective servo areas by filling pores having the nano structure with magnetic substance and providing a plurality of periodic array structures in the servo areas.

DISCLOSURE OF INVENTION

That is, the present invention is a structure comprising a first area having a plurality of pores which have only a first period and a second area having a plurality of pores which have only a second period, characterized in that the first area and the second area share a plurality of pores.

Furthermore, the present invention is a structure comprising periodic array structures of pores formed in an anodized oxide film, characterized in that a plurality of types of periodic array structures are arranged adjacent to one another.

The above described plurality of types of periodic array structures are preferably arranged adjacent to one another and there are preferably at least two pores in the shared region which constitutes the boundary thereof.

The above described plurality of types of periodic array structures preferably have at least one pore in addition to the pores in the shared region.

The above described plurality of types of periodic array structures each preferably have equal distances between first proximate pores or have the distance between first proximate pores on one side equal to the distance between second proximate pores on the other side or have equal distances between

second proximate pores.

The distance between the most proximate pores of the above described plurality of types of periodic array structures is preferably 0.75B to 1.5B (where B is a numerical value [nm] included within the range between a maximum value and a minimum value of the distance between the most proximate pores of the above described plurality of types of periodic array structures).

According to an aspect of the present invention, there is provided a structure comprising: a first area comprising a plurality of pores which have a first period; and a second area comprising a plurality of pores which have a second period, wherein the first area and the second area own a plurality of pores in common.

According to another aspect of the present invention, there is provided a structure comprising a plurality of pore groups having a periodic array structure formed in an anodization film, wherein the pore groups is arranged adjacent to at least any one of the pore groups.

In the above structure, the pore groups are arranged adjacent to one another by owning at least two pores in common. Each of the pore groups may comprise pores not owned in common. Alternatively, the periodic array structure have a period different

from the period of the adjacent pore group.

In the above structure, the distance between the most proximate pores of the plurality of types of periodic array structures are 0.75B to 1.5B (where B is a numerical value [nm] included within the range between a maximum value and a minimum value of the distance between the most proximate pores included in the plurality of types of periodic array structures).

In the above structure, the distance between the pores making up unit lattices of the plurality of types of periodic array structures are prefarably a to 2a (where a is the distance [nm] between the most proximate pores included in the plurality of types of periodic array structures).

The above described plurality of types of periodic array structures is preferably a rectangular lattice, tetragonal lattice, hexagonal lattice, graphite-shaped lattice or parallelogram lattice.

The above described anodized oxide film is preferably comprised of aluminum as a principal component.

At least one of the above described pores preferably includes a filler.

The above described filler is preferably a dielectric having a dielectric constant different from that of the above described anodized oxide film, semiconductor, magnetic material or light-emitting

material.

Furthermore, the present invention is an optical device characterized in that the pores of the above described structure are filled with a dielectric having dielectric constant different from that of the above described anodized oxide film.

Furthermore, the present invention is a light-emitting device characterized in that the pores of the above described structure are filled with a light-emitting material.

Furthermore, the present invention is a magnetic device characterized in that the pores of the above described structure are filled with a magnetic material.

Furthermore, the present invention is a magnetic recording medium comprising a data area where pores filled with the above described magnetic material record information and a servo area where track positions are detected, characterized in that the structure made up of simple periodic arrays of the above described pores differs between the data area and the servo area.

At least one pore in the above described servo area is preferably shifted by half a period with respect to the period of pores perpendicular to the track direction of the data area.

The above described servo area is preferably

constructed of at least two types of periodic array structures.

Furthermore, the present invention is a method of manufacturing a structure in which a plurality of pore periodic array structures formed in an anodized oxide film having different periods are arranged adjacent to one another, comprising (1) a step of forming pore starting points made up of a plurality of types of periodic arrays on the surface of a substrate comprised of aluminum as a principal component and (2) a step of anodizing the above described substrate simultaneously at the same anodization voltage.

The plurality of periodic array structures having different periods are preferably arranged adjacent to one another and there are at least two pores in the shared region which is the boundary thereof.

The plurality of periodic array structures having different periods preferably have at least one pore in addition to the pores in the above described shared region.

A voltage applied during anodization of the structure of the above described plurality of periodic arrays is preferably A [V] (B [nm] = A [V]/2.5 [V/nm], where B is a numerical value included within the range between a maximum value and a

minimum value of the distance between the most proximate pores included in the above described plurality of types of periodic array structures).

The above described step (1) is preferably formed by an optical lithography, X-ray lithography, electron beam lithography, ion beam lithography, imprint lithography or scanning prove microscopy (SPM) lithography.

Furthermore, the present invention is a structure characterized by being manufactured using the above described method.

The present invention will be explained in detail below.

The structure of the present invention includes a nano structure as a typical example thereof, and therefore the nano structure will be explained.

The nano structure according to the present invention is a structure with a periodic array of pores formed in an anodized oxide film and array structures with a plurality of types of periods are arranged adjacent to one another.

The pores according to the present invention include pores filled with a material after those pores are formed.

The method of manufacturing the nano structure of the present invention consists of forming desired pore starting points made up of a plurality of

periodic array structures on the surface of a substrate comprised of aluminum as a principal component using a lithographic method, etc., and applying anodization to these pore starting points at an appropriate applied voltage. The structure formed with the distance between most proximate pores of the periodic array structures limited to 0.75B to 1.5B (where B is a numerical value [nm] included within the range between a maximum value and a minimum value of the distance between the most proximate pores of the plurality of types of periodic array structures) allows a batch of anodization at a single voltage. Here, the nano structure refers to a structure having a shape variation or composition variation with the period of the concavo-convex structures being 1 μm or less.

The nano structure of the present invention is a structure with a periodic array of pores formed in an anodized oxide film and is a structure in which a plurality of periodic arrays having different periods are arranged adjacent to one another. Furthermore, there are at least two pores in a shared region which is the boundary of the adjacent periodic arrays and there is at least one pore in addition to the pores in the shared region. The distance between the most proximate pores of the periodic array structures is preferably 0.75B to 1.5B (where B is a numerical

value included within the range between a maximum value and a minimum value of the plurality of periods). For example, when pore starting points made up of a hexagonal lattice having a period of 200 nm is subjected to anodization with an anodization voltage of 40 V applied, because 40 V × 2.5 [nm/V] = 100 nm, 40 V corresponds to the anodization voltage of a period of 100 nm, and therefore pores are also formed in areas where no pore starting points exist. Therefore, to perform a batch of anodization on array structures of a plurality of types of periods, the smaller the distance between most proximate pores of a plurality of types, the better, and the probability that pores may also be formed from places other than the pore starting points increases when the distance exceeds the range of 0.75B to 1.5B. For these reasons, the voltage in a batch of anodization (step (2)) is preferably calculated from the most proximate distances which are most numerous in the structure.

FIG. 1 is a plan view illustrating the nano structure of the present invention. For example, using a technique such as an optical lithography, pore starting points 1 of a plurality of periodic array structures 6 made up of a hexagonal lattice area 3, a rectangular lattice area 4 and a graphite-shaped lattice area 5 are formed on the surface of a substrate as shown in FIG. 1. At this time, periodic

structures such that pores located on the boundaries among a plurality of periodic array structures 6 are shared are arranged continuously. A normal anodization voltage is uniquely determined depending on the period of pores, but when pore starting points are formed, it is possible to obtain pores having the same period as the starting point period regardless of a certain degree of voltage shifts. That is, with pore starting points whose period varies only slightly, it is possible to form regularly arrayed high aspect pores in a short time without producing any disorder of arrays. As the method of forming starting points of pore formation, it is also possible to actually forme dents on the surface of a film to be subjected to anodization or mask areas other than starting points. Or it is also possible to form an anodization film on a substrate having projections and depressions with predetermined periodicity and use projections and depressions reflecting the projections and depressions of the base as starting points.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view illustrating a nano structure of the present invention;

FIGS. 2A, 2B and 2C are plan views illustrating the nano structure of the present invention;

FIG. 3 is a schematic view illustrating a nano structure according to Embodiment 2 of the present invention; and

FIG. 4 is a perspective view illustrating a nano structure of according to Embodiment 3 of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference now to the attached drawings, embodiments of the present invention will be explained in detail below. The same reference numerals will denote the same parts in all drawings.

(Embodiment 1)

First, as step (2), concave structures having desired arrays are formed on the surface of a substrate on which an aluminum thin film is formed using an electron beam direct drawing method and these are used as pore starting points. As shown in FIG. 1, the array of pore starting points 1 consists of a hexagonal lattice area 3, a rectangular lattice area 4 and a graphite-shaped lattice area 5 arranged adjacent to one another and pores on the boundary of the adjacent areas are shared by both areas. That is, the two adjacent areas share an array of pores with equal periodicity on the boundary. Black bullets 1 in FIGS. 2A to 2C indicate projected positions of pores on a plane of the hexagonal lattice area,

rectangular lattice area and graphite-shaped lattice area in FIG. 1. In FIGS. 2A to 2C, a period 8 of the hexagonal lattice area 3 is 200 nm, a period of the rectangular lattice area 4 in the Y direction 9 is 200 nm, that of the X direction is 250 nm and the most proximate distance 10 of the graphite-shaped lattice area 5 is 200 nm. According to this structure, when B = 200 nm that is minimum value in periods, the allowed periodic array structures are in the range of 150nm to 300nm, these are included in 0.75B to 1.5B.

Then, all the pore starting points formed in step (2) are subjected to anodization simultaneously at the same voltage. As the anodization voltage, a voltage [V] obtained by {basic period [nm] ÷ 2.5 [nm/V]} is generally considered optimum. Since the most numerous most proximate distance is 200 nm, if the basic period (anodization period) is assumed to be 200 nm, the anodization voltage becomes 80 V. When a substrate is immersed in an aqueous solution of 0.3 mol/L phosphoric acid at 20°C and anodization is applied using this as the anode with 80 V applied, then aluminum is oxidized and dissolved from the pore starting points and high aspect pores are formed.

Then, pore walls of aluminum oxide are dissolved in the aqueous solution of phosphoric acid and pore diameters are thereby expanded and

controlled. FIGS. 2A, 2B and 2C show pores after the pore diameters are expanded. The shape of pore 7a in the hexagonal lattice area is substantially circular as shown in FIG. 2A, the shape of pore 7b in the rectangular lattice area is rectangular as shown in FIG. 2B and the shape of pore 7c in the graphite-shaped lattice area is triangular with no pores formed from areas without pore starting points through anodization under this condition, as shown in FIG. 2C.

(Embodiment 2)

As a magnetic device, pores with hexagonal lattice areas and rectangular lattice areas having the same period as that of Embodiment 1 which are repeatedly arranged adjacent to one another are formed. FIG. 3 shows arrays of pores. The method of formion is the same as that in Embodiment 1. Cobalt is charged into the pores formed by an electric plating method to convert the area to a magnetic recording area. In this magnetic device, a direction 13 is regarded as the track orientation and the magnetic device is used, divided into a servo area 11 and data area 12. Some magnetic substance cell groups in the servo area are half a period shifted from the period of the magnetic substance cell groups in the direction perpendicular to the track direction and this is effective for performing position control

Furthermore, the present invention can provide a magnetic recording medium capable of constructing an effective servo area by filling the pores having the nano structure with magnetic substance and providing a plurality of periodic array structures in the servo area.

(called "off track") of the head and tracks. This prevents information of the adjacent tracks from being mistakenly reproduced or information from being overwritten on the already recorded adjacent tracks. Reducing the servo area through these arrays makes it possible to secure the data area and realize a much higher density. In FIG. 3, reference numeral 14 denotes pores in the shared region.

(Embodiment 3)

As a device, pores with hexagonal lattice areas arranged on both sides of a rectangular lattice area are formed. The method of formion is the same as that of Embodiment 1 and then polystyrene with light-emitting pigment is charged into the pores. Since the photonic band structure of the rectangular lattice area is different from that of the hexagonal lattice area, wavelengths which are easily guided vary depending on their respective structures. For this reason, when light wave which propagates through the rectangular lattice area but does not propagate through the hexagonal lattice area is introduced into the pores in the rectangular lattice area in the vertical direction 16 (see FIG. 4) and if this structure is regarded as a light waveguide, the rectangular lattice area becomes a core and the hexagonal lattice area becomes a cladding and light wave propagates with lower loss compared with a

normal two-dimensional light waveguide. Filling arbitrary pores in the core area with a light-emitting pigment makes it possible to excite and make propagate light waves with different wavelengths and this is applicable to an optical device. In FIG. 4, reference numeral 15 denotes a light-emitting material and 17 denotes a light-emitting direction.

As described above, the present invention can provide a nano structure having pore array structures in which a plurality of periodic arrays are arranged adjacent to one another.

Furthermore, the present invention can provide a method of manufacturing a nano structure in which a plurality of periodic arrays are formed adjacent to one another in a short time by applying anodization to pore starting points formed on a substrate all together at an anodization voltage.

Furthermore, the present invention can provide an optical device with the pores having the nano structure filled with a dielectric having a dielectric constant.

Furthermore, the present invention can provide a light-emitting device with the pores having the nano structure filled with a light-emitting material.

Furthermore, the present invention can provide a magnetic device with the pores having the nano structure filled with a magnetic material.

CLAIMS

1. A structure comprising a first area including a plurality of pores which have a first period and a second area including a plurality of pores which have a second period, characterized in that the first area and the second area share a plurality of pores.

2. A structure comprising periodic array structures of pores formed in an anodized oxide film, wherein a plurality of types of periodic array structures are arranged adjacent to one another.

3. The structure according to claim 2, wherein a plurality of types of the periodic array structures are arranged adjacent to one another and there are at least two pores in the shared region which constitutes the boundary thereof.

4. The structure according to claim 2, wherein a plurality of types of the periodic array structures have at least one pore in addition to the pores in the shared region.

5. The structure according to claim 2, wherein a plurality of types of the periodic array

structures each have equal distances between first proximate pores or have the distance between first proximate pores on one side equal to the distance between second proximate pores on the other side or have equal distances between second proximate pores.

6. The structure according to claim 5, wherein the distance between the most proximate pores of a plurality of types of the periodic array structures is 0.75B to 1.5B where B is a numerical value [nm] included within the range between a maximum value and a minimum value of the distance between the most proximate pores of the above described plurality of types of periodic array structures.

7. The structure according to claim 2, wherein said periodic array structures is a rectangular lattice, tetragonal lattice, hexagonal lattice, graphite-shaped lattice or parallelogram lattice.

8. The structure according to claim 2, wherein said anodized oxide film is comprised of aluminum as a principal component.

9. The structure according to claim 2, wherein at least one of said pores includes a filler.

10. The structure according to claim 9, wherein said filler is a dielectric having a dielectric constant different from that of said anodized oxide film, semiconductor, magnetic material or light-emitting material.

11. An optical device wherein said pores of the structure according to claim 2 are filled with a dielectric having dielectric constant different from that of said anodized oxide film.

12. A light-emitting device wherein said pores of the structure according to claim 2 are filled with a light-emitting material.

13. A magnetic device wherein said pores of the structure according to claim 2 are filled with a magnetic material.

14. A magnetic recording medium comprising:

a data area where pores filled with said magnetic material to record information; and

a servo area where track positions are detected,

wherein the structure made up of simple periodic arrays of said pores differs between said data area and said servo area.

15. The magnetic recording medium according to claim 14, wherein at least one pore in said servo area is shifted by half a period with respect to the period of pores perpendicular to the track direction in the data area.

16. The magnetic recording medium according to claim 14, wherein said servo area is constructed of at least two types of periodic array structures.

17. A method of manufacturing a structure in which a plurality of pore periodic array structures formed in an anodized oxide film having different periods are arranged adjacent to one another, comprising:

(1) a step of forming pore starting points made up of a plurality of types of periodic arrays on the surface of a substrate comprised of aluminum as a principal component; and

(2) a step of anodizing said substrate simultaneously at the same anodization voltage.

18. The method of manufacturing a structure according to claim 17, wherein said plurality of periodic array structures having different periods are arranged adjacent to one another and there are at least two pores in the shared region which is the

boundary thereof.

19. The method of manufacturing a structure according to claim 17, wherein said plurality of periodic array structures having different periods have at least one pore in addition to the pores in said shared region.

20. The method of manufacturing a structure according to claim 17, wherein a voltage applied during anodization of the structure of said plurality of periodic arrays is A [V] (B [nm] = A [V]/2.5 [V/nm], where B is a numerical value included within the range between a maximum value and a minimum value of the distance between the most proximate pores included in said plurality of types of periodic array structures).

FIG. 1

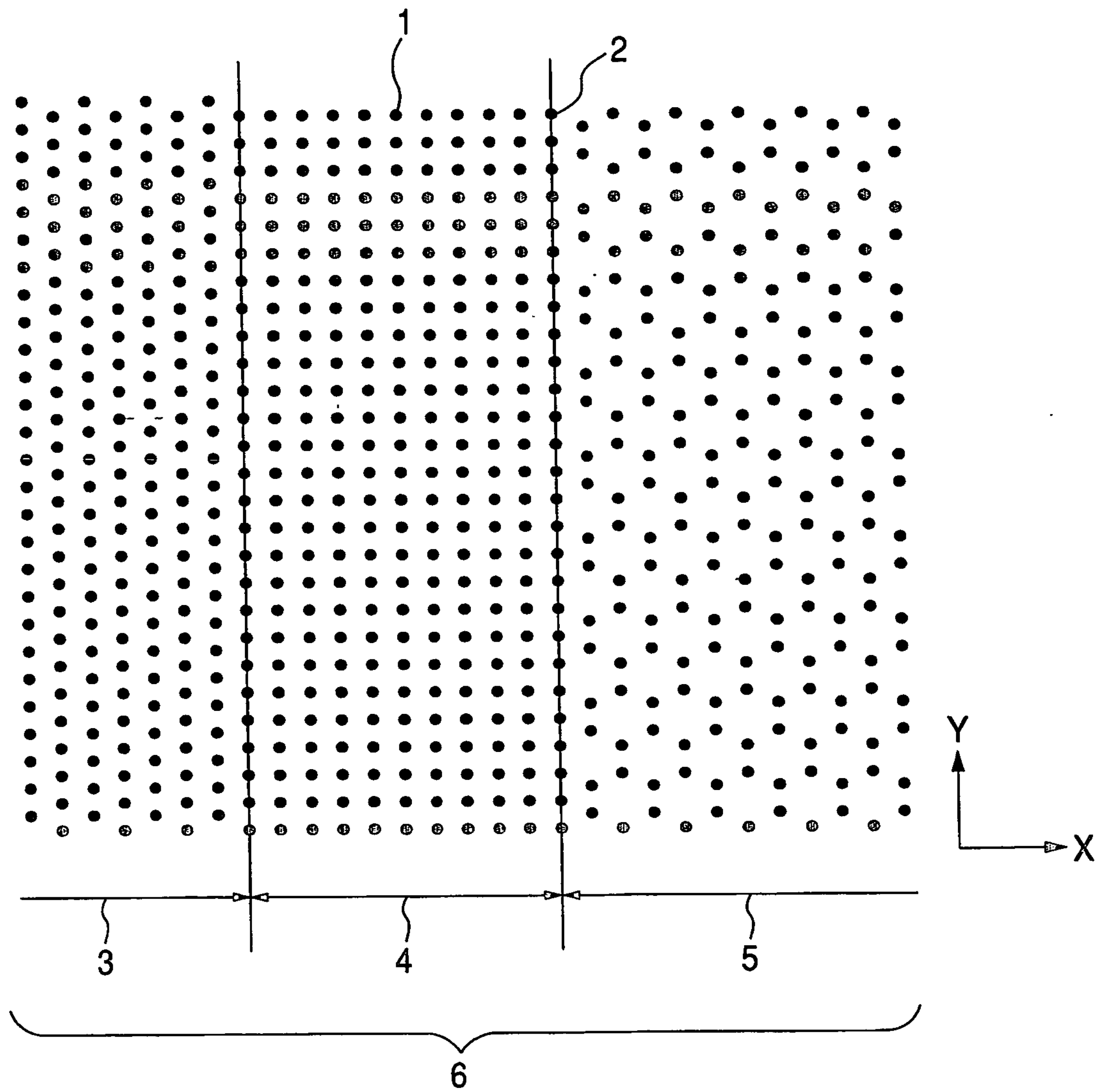


FIG. 2A

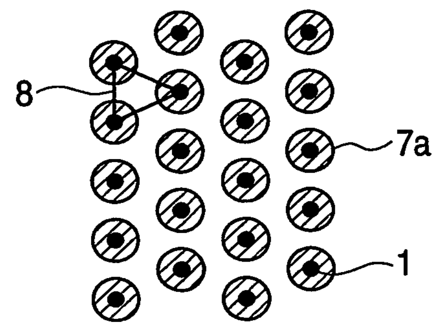


FIG. 2B

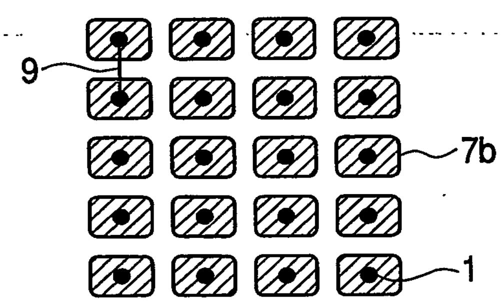
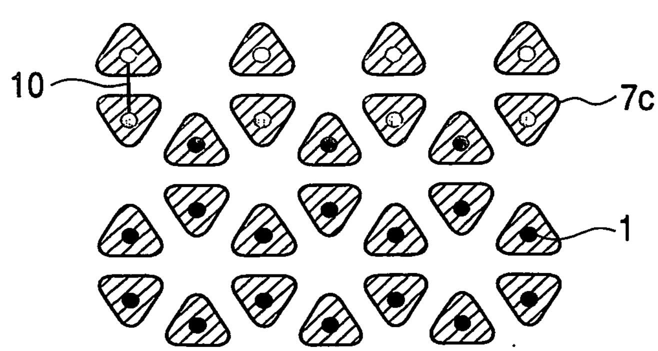


FIG. 2C



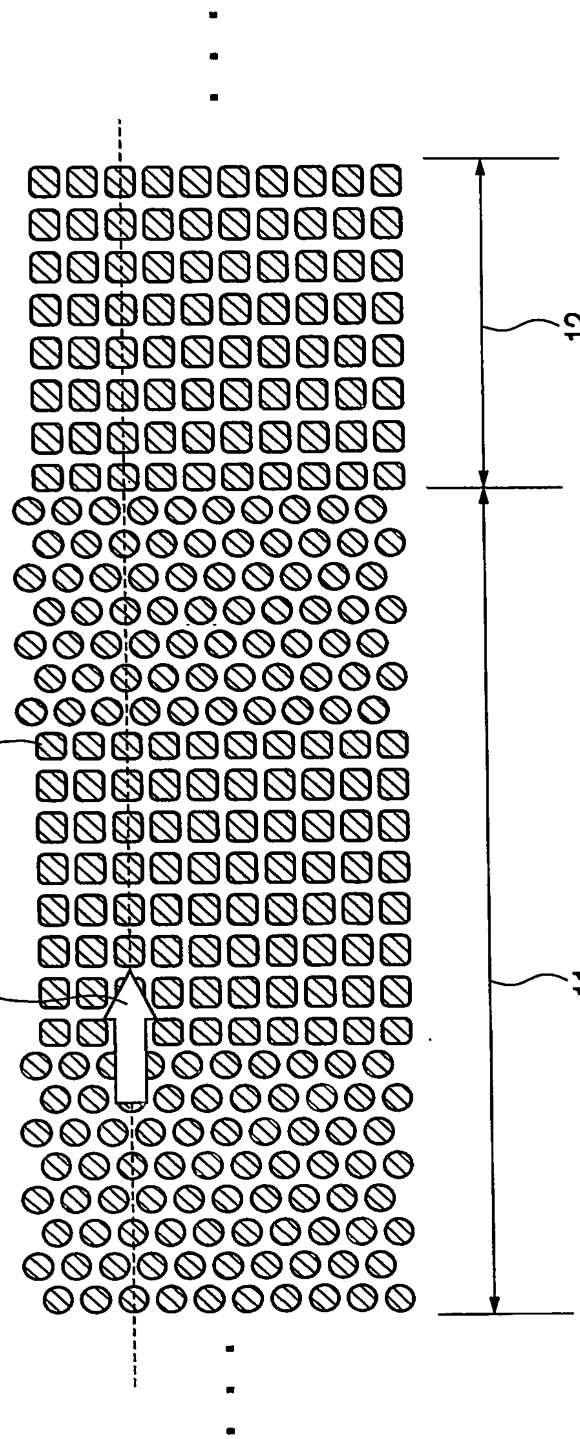
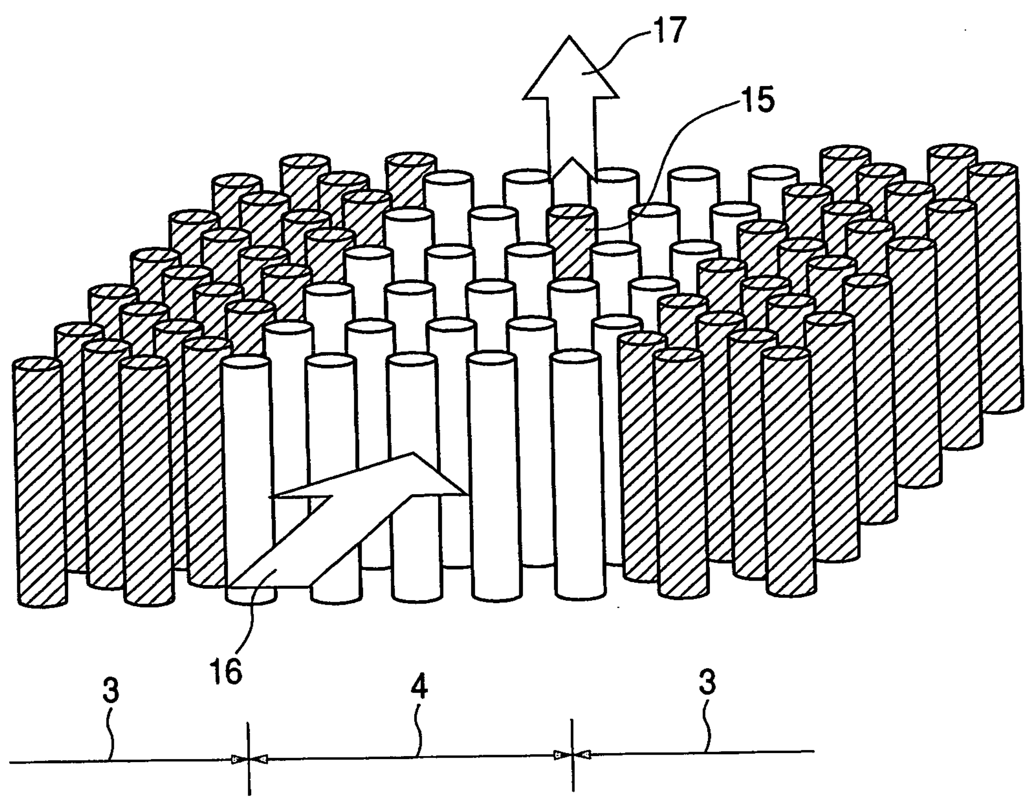


FIG. 3

FIG. 4



INTERNATIO SEARCH REPORT

Int l Application No
P P2004/001281

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B5/62 G11B5/84 C25D11/04 C25D11/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B C25D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) & JP 11 224422 A (NIPPON TELEGR & TELEPH CORP <NTT>; NTT ADVANCED TECHNOLOGY C), 17 August 1999 (1999-08-17) cited in the application abstract -----	1-9, 13-16
X	US 6 139 713 A (TAMAMURA TOSHIAKI ET AL) 31 October 2000 (2000-10-31) cited in the application the whole document -----	17-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 July 2004	16/07/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Benfield, A

5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/001281

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 10-12
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 10-12

Claim 1 describes such a multiplicity of possible structures that a meaningful search of all possible structures is rendered impossible. On the other hand, it has been possible to search a limited subset of the possible applications in the light of the best-described application, the application described in independent claim 14 (a magnetic medium).

Claim 10, furthermore, refers to 'said anodised oxide film, semiconductor, magnetic material or light-emitting material', none of which have been referred to in previous claims.

As remarked above, claim 1 describes such a multiplicity of possible structures that a meaningful search of all possible structures is rendered impossible. This situation is further compounded by the addition of claims 11-13, which claim respectively an 'optical device', 'light-emitting device' and a 'magnetic device' using the structure of claims 1-10 as a basis. These claims clearly share the problem of broadness exhibited by claim 1 as well as individually claiming such a multiplicity of possible structures that a meaningful search of all possible structures is rendered impossible.

While claims 1-9 and 13 have been searched in a limited fashion (see remarks above), in the case of claims 10, 11 and 12 a meaningful search of any kind was impossible.

In addition to the above remarks, the wording of claims 5 and 6 is such that their meaning is rendered obscure. The unclear formulation 'proximate pores' is largely responsible for this. Claim 6 is also defined partly by an undisclosed parameter B.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP2004/001281

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
JP 11224422	A	17-08-1999	NONE			
US 6139713	A	31-10-2000	CN	1222943	A ,B	14-07-1999
			EP	0931859	A1	28-07-1999
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